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Upcycling Polypropylene Strapping Bands for Wearable Accessory Design

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Abstract

The purpose of this research was to investigate the processing of waste polypropylene strapping bands to be used as alternative materials for sustainable wearable jewelry design. The research process consists of experimenting with materials and production techniques, such as material digestion and processing of materials. It is also used to create parts in the form of oval granules, which are then assembled into wristwatch products. The results showed that polypropylene strapping strips can be effectively melted and remolded. A temperature of 200 degrees Celsius is the ideal condition for melting the material to a uniform consistency. The resulting material can support the CNC cutting process well and is suitable for use as wearable jewelry. This research demonstrates the potential of using industrial waste plastics to add value in the context of sustainable design and can be used to guide the development of future wearables and materials

Keywords: Material Processing, Polypropylene, Upcycling, Wearable Accessory

1. Introduction

The plastic waste problem is one of the major environmental challenges in the world today. Transportation and consumption continue to increase. As a result, a large amount of plastic waste accumulates in the ecosystem. Many types of plastics have a long degradation life, and without proper management, they can lead to soil pollution problems. This has become an urgent issue that needs to be addressed systematically. (Evode et al., 2021; Kibria, 2023)

One of the most widely used plastics in the logistics and industrial sectors is polypropylene strapping bands, which are used to fasten and secure goods during transportation. But after a single use, plastic straps are most often discarded as waste without being properly recycled. This results in a large amount of industrial waste. Although the material still has the potential to be processed and used.(Daoudi et al., 2024)

Therefore, the concept of sustainable development and sustainable design plays an important role by focusing on the efficient use of resources. This concept is in line with the principles of the circular economy, which supports design that takes into account the life cycle of materials and the processing of materials so that they can be reused in new contexts. In particular, the use of waste plastic materials to develop into materials for creative design.(Velenturf & Purnell, 2021)

At the same time, wearable accessory products continue to grow in popularity because they reflect the identity, lifestyle, and values of users. In addition, consumer trends are also focusing on products with a sustainable and environmentally friendly story. As a result, wearable

accessory design has become an important area for experimentation and application of alternative materials with aesthetic and environmental value at the same time.(Mayusoh et al., 2023)

From this context, therefore, this research aims to study the processing process of waste polypropylene strapping bands. Through material and design experimentation to lead to the development of sustainable materials for wearable accessories. The results of the research are expected to reduce the amount of plastic waste from the industrial sector. It adds value to waste materials and offers a new approach to material design for wearable products that can be extended to future commercial development and sustainable design.

1.1 Research Objective

1.1.1 To experiment with processing waste polypropylene strapping bands as materials in designs.

1.1.2 To design a wearable accessory from processing polypropylene strapping bands

2. Literature review

Plastic waste and waste material management

Numerous environmental studies suggest that the amount of plastic waste from the industrial and consumer sectors is on the rise. Especially thermoplastic plastics, which can be melted and reprocessed. However, it has been reused in a small proportion. Several researchers have proposed that managing plastic waste with the concept of reuse and value-added upcycling is a more potent approach to reducing environmental impact than traditional disposal methods such as landfill or incineration. This is in line with the circular economy concept that focuses on reducing waste at the source of the production process. (Macheca et al., 2024; Pandey et al., 2023; Balu et al., 2022)

Properties of polypropylene and its processing potential

Polypropylene (PP) is a type of thermoplastic that is widely used in the industrial sector. This is due to its outstanding properties of strength, lightweight, toughness, and tensile strength, as well as good resistance to chemicals and moisture. Several studies suggest that polypropylene can be melted and reprocessed many times while its physical properties remain at a level suitable for use. Polypropylene strapping strips, which are products of the same group. Therefore, it has a high potential to be processed into new sheet materials or parts. Materials and design research has experimented with the use of this type of plastic in the product design process. It has been found that the thickness, color, and texture of the material can be controlled through the process of melting and molding. This makes the material suitable both structurally and aesthetically.(Hossain et al., 2024; Alsabri et al., 2022)

Sustainable Design Concepts and Sustainable Materials

The sustainable design concept focuses on the choice of environmentally friendly materials. Reducing impact throughout the product lifecycle and designing materials that can be reused. A lot of design research has highlighted the role of materials as a key component of sustainability. It sees materials not only as the structure of the product but also as a communicator of ideas.(Limthattanakun, 2024) Value and Identity of Design The use of waste materials to develop alternative materials for wearable product design is an approach that has received more attention. In particular, the processing of materials through a creative

experimental process opens up opportunities for new materials with unique characteristics and meets the needs of contemporary applications.(Sapuan & Mansor, 2021; Ashby, 2022)

Wearable Accessory Design and Contemporary Trends

Wearable accessories are a product group that plays an important role in reflecting the personal identity and lifestyle of users. Contemporary design research suggests that jewelry does not only serve as a decoration of the body. It is also a medium for communicating social ideas. Culture and the environment. (Mayusoh et al., 2025) The trend of wearable accessory design has turned to a greater emphasis on alternative materials and sustainability concepts. Designers began experimenting with the use of recycled and waste materials from different industries in their creations, creating new value for materials and responding to the needs of environmentally conscious consumers. (Bin & Lili, 2022)

From the review It was found that most of the research focused on plastic waste management and the development of recycled materials in industry. Studies focusing on experimental processing of polypropylene fasteners for use in the context of wearable jewelry design are still limited. This research has a role to play in filling that gap. It presents an experimental approach to processing waste materials through design processes and manufacturing technology to create alternative materials for sustainable wearable accessories.

3. Methodology

This research is an experimental design research that focuses on the process of processing waste materials along with the design and development of wearable accessory products. The research process is divided into 2 main stages as follows:

Step 1: Material and Technique Experimentation focuses on material and technique experiments to study the feasibility of using waste polypropylene strapping bands to process them into alternative materials for wearable accessory designs.




Step 2: Design and Product Development, is the use of the results of material and technical experiments from Step 1 and synthesizing them into a design concept by taking into account the identity of the material. The concept of sustainability and practicality of wearable accessories is then carried out to develop product prototypes.

4. Results

Studies of the properties of polypropylene strapping bands have shown that this material is classified as a thermoplastic, which can be melted and remolded when properly heated. It retains sufficient levels of toughness, flexibility, and strength for product applications. Such properties give polypropylene strapping bands a high potential to be processed into sheet materials for wearable accessory designs. This is especially true in processes where the shape and thickness of the material are controlled.

Based on the data that has been brought to the experiment, the melting of polypropylene strapping bands is carried out at different temperatures. To study the suitability of temperature for processing materials into sheets. The results of the experiment are summarized as shown in Table 1.

Table 1: Results of melting of polypropylene strapping bands at different temperatures

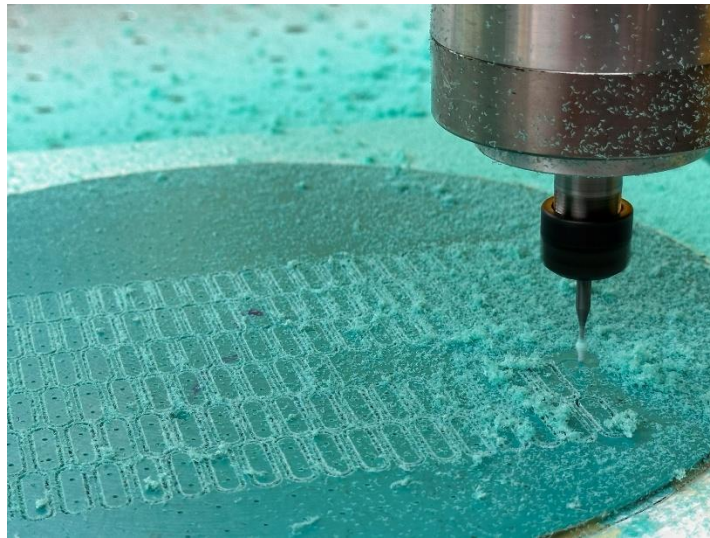
Temperature (°C)	Melting effect	Characteristics of the resulting material	
150	It melts unevenly.		The material remains fragmented into some pieces. The surface is uneven, and it cannot be formed into sheets of uniform strength.
200	Optimum melting		Homogeneous fused material, smooth surface. It can control the thickness and form the sheet well.
250	Burn Materials		Discoloration and deterioration of the material occur. As a result, it is not suitable for use.

*** 100 g Polypropylene Strapping Bands /Time 30 minutes

The results of the experiment showed that the temperature was 200 degrees Celsius. It is the most suitable temperature for melting polypropylene strapping bands, as the quality of the material can be controlled in terms of both structure and aesthetics. Temperatures that are too low or too high affect processing efficiency.

Through experiments with polypropylene sheets that have been melted at the right temperature and cut with CNC machines, it was found that the material can support the cutting process well. The precision of the shape and the edges of the workpiece are neat at a level suitable for use as a piece of wearable accessory. The designed shapes can be produced uniformly and do not crack or deform during the cutting process, which reflects the suitability of the material for use in conjunction with modern production technology.

Figure 1 shows CNC cutting.



Based on the results of material and technical experiments. The production process of wearable accessories can be summarized in the following order:

1. Material preparation: Cutting the polypropylene strapping bands into small pieces of about 2 cm to make them suitable for melting and controlling the quality of the material.
2. Melting the material is carried out by placing the prepared material pieces in a container and placing them in an oven at 200 degrees Celsius for 30 minutes to allow the material to be homogeneous and form a sheet.
3. Cutting into shapes with CNC machines by taking the obtained material sheets and cutting them with CNC machines according to the designed design by dividing the parts into 2 main parts: the housing and the cable part.
4. Assembling the workpiece Take the cut parts and assemble them. Using spare parts of the watch as connecting elements to ensure practicality and proper strength.

Figure 2 shows the production process.

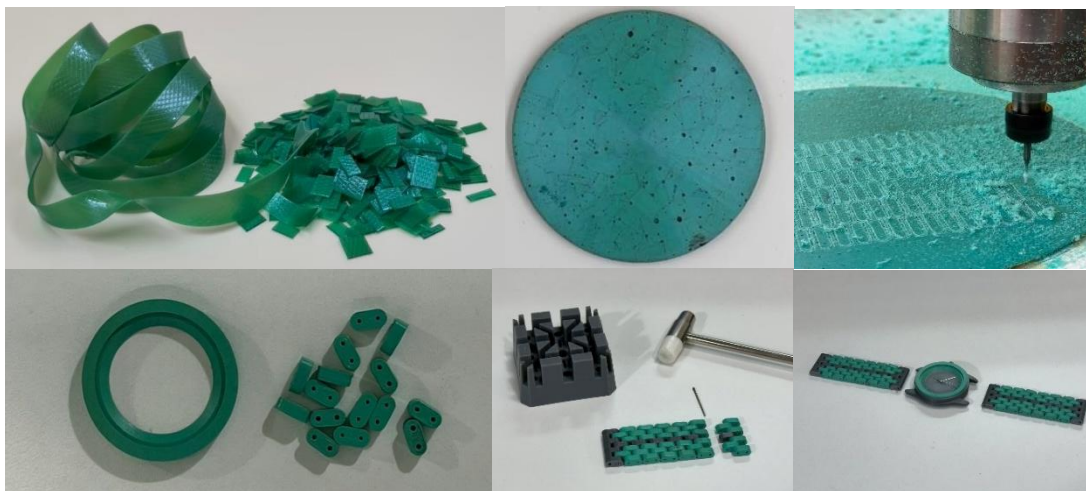
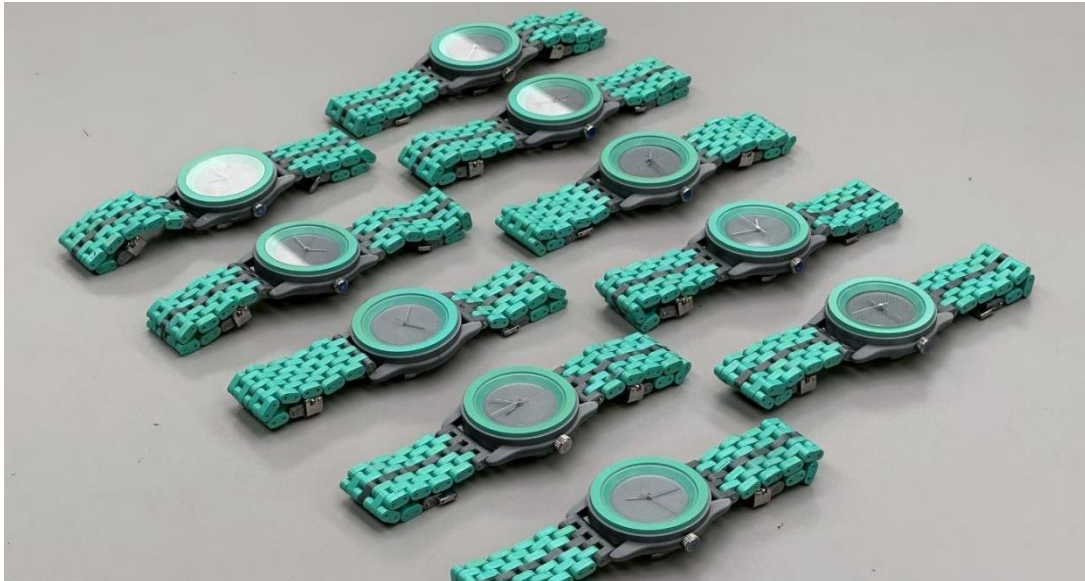


Figure 3: Product Prototype



5. Conclusion

The results reflect that waste polypropylene strapping bands have a high potential to be processed into alternative materials for wearable accessory design. Through the experimental process of materials and manufacturing techniques. Melting materials at the right temperature plays an important role in the quality of the processed material, with experiments showing that a temperature of 200 degrees Celsius can make the material homogeneous. It is smooth and uniform. This is conducive to the next stage of processing. Temperatures that are too low or too high result in the quality of the material being unsuitable for use.

The use of CNC technology in the material processing process improves the precision of part production and opens up the possibility of more complex shape designs. The experimental results show that the melted polypropylene material can support the cutting process well without cracking or deformation. The resulting oval grain shape is uniform and can be effectively assembled into pieces of wearable accessory. This is in line with a design concept that combines modern manufacturing technologies with sustainable materials.

In terms of product design. The combination of polypropylene strapping bands and spare parts increases the potential of use and creates a link between the processed material and the actual wearable system. Such an approach not only enhances the aesthetic value of waste materials but also promotes designs that can be used for practical and commercial purposes.

However, this research has limitations in the field of mechanical properties testing according to industry standards. This may affect its use on a large scale in the future. Further studies should consider further engineering tests, including environmental impact studies throughout the material life cycle, to increase reliability and expand the application range of processed materials.

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